9

Management Actions To Mitigate Potential Adverse Environmental Impacts

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9. MANAGEMENT ACTIONS TO MITIGATE POTENTIAL ADVERSE ENVIRONMENTAL IMPACTS

This chapter describes management actions that the U.S. Department of Energy (DOE or the Department) is considering to reduce or mitigate adverse impacts to the environment that could occur if the Department implemented the Proposed Action to construct, operate and monitor, and eventually close a geologic repository for the disposal of spent nuclear fuel and high-level radioactive waste at Yucca Mountain. In keeping with previous chapters in this environmental impact statement (EIS), this chapter contains separate discussions for the mitigation of repository impacts and the mitigation of impacts from transportation activities. Mitigation includes activities that (1) avoid the impact altogether by not taking a certain action or parts of an action; (2) minimize impacts by limiting the degree or magnitude of the action and its implementation; (3) repair, rehabilitate, or restore the affected environment; (4) reduce or eliminate impacts over time by preservation or maintenance operations during the life of the action; or (5) compensate for the impact by replacing or substituting resources or environments.

This chapter also describes mitigations in environmental resource areas where DOE has identified adverse impacts and analysis has indicated that mitigation has the potential to reduce those impacts. This chapter does not discuss mitigations for environmental resource areas for which analyses have not identified a potential for impacts.

Changes in repository design have resulted in modifications to some planned or potential mitigation measures identified in the Draft EIS. In addition, DOE has identified some new mitigation measures.

Apart from the impact findings and mitigations discussed in this EIS, Section 116(c) of the Nuclear Waste Policy Act, as amended (NWPA) states that "the Secretary shall provide financial and technical assistance to (an affected unit of local government or the State of Nevada)… to mitigate the impact on such (an affected unit of local government or the State of Nevada) of the development of (a) repository and the characterization of (the Yucca Mountain) site." Such assistance can be given to mitigate likely "economic, social, public health and safety, and environmental impacts." Within that broad framework, neither Section 116 nor any other provision of the NWPA limits the impacts that are subject to assistance under Section 116 to the environmental impacts considered in this EIS.

The fact that the EIS analysis has determined that the implementation of the Proposed Action would not cause substantial socioeconomic impacts to communities in Nevada or to the State of Nevada does not prevent local governments or the State government from receiving assistance to address economic, social, public health, or environmental impacts under Section 116(c).

The Section 116 impact assistance review process and the Yucca Mountain Repository EIS process are distinct from one another, and the implementation of one would not depend on the implementation of the other. The provision of assistance under Section 116 would not necessarily be limited either by the impacts identified in this EIS or by its findings on such impacts. Any decision to provide assistance under Section 116 will be based on an evaluation of a report submitted by an affected unit of local government or the State of Nevada pursuant to Section 116 to document likely economic, social, public health and safety, and environmental impacts.

9.1 Types of Management Actions

The design, construction, operation and monitoring, and closure planning for the proposed repository incorporate physical features, procedures, and safeguards to reduce environmental consequences. Some of these features, procedures, and safeguards are the result of DOE determinations based on site characterization activities and the ongoing evaluation of planning and design for the proposed repository.

To complement the measures already incorporated, DOE is considering a range of additional mitigation measures aimed at reducing consequences of the proposed repository project. The repository and transportation mitigation analyses in this chapter discuss impact reduction measures that DOE expects to implement as well as other mitigations DOE is considering.

9.1.1 DOE-DETERMINED IMPACT REDUCTION FEATURES, PROCEDURES, AND SAFEGUARDS

DOE has studied the Yucca Mountain site, vicinity, and regions of influence for more than a decade and has accumulated considerable knowledge. The Department has identified many improvements in its project design and plan to reduce potential impacts. The Proposed Action includes commitments to reduce impacts that DOE has made as a result of its site characterization studies and the ongoing evaluation of repository planning and design. DOE would undertake these measures if the Secretary of Energy recommended the site for development and authorization was provided to proceed with the Proposed Action. This chapter identifies these commitments in appropriate areas.

9.1.2 MITIGATION MEASURES UNDER CONSIDERATION FOR INCLUSION IN PROJECT PLAN AND DESIGN

DOE has conducted extensive site characterization studies, and continues to evaluate whether to commit to additional mitigation measures in the event the site is designated and the Nuclear Regulatory Commission grants a license for the repository project. DOE is considering these additional measures to reduce the potential effects of the repository project. This chapter identifies measures under consideration in appropriate subject areas.

9.1.3 ONGOING STUDIES THAT COULD INFLUENCE MITIGATION MEASURES IN THE PROJECT PLAN AND DESIGN

Accelerator Transmutation of Waste technology has been under consideration for many years as a process for the treatment of nuclear waste. This technology would involve the use of a chemical separation process, a linear accelerator, and a subcritical nuclear assembly. The chemical process would separate transuranic and certain long-lived radioisotopes from the spent nuclear fuel. The linear accelerator and subcritical nuclear assembly would change the transuranic and long-lived radioisotopes into short-lived radioisotopes and stable (nonradioactive) elements.

The National Research Council studied Accelerator Transmutation of Waste and other technologies for use in the treatment of spent nuclear fuel (DIRS 103403-National Research Council 1996, all). The study concluded that:

- The use of separation and transmutation to treat spent nuclear fuel is technically feasible.
- Treatment would cost many tens of billions of dollars and require many decades to implement.
- While other technologies would be based on considerable experience, Accelerator Transmutation of Waste technology would require extensive development before DOE could realistically assess its technical feasibility.
- No separation and transmutation technology offers sufficient promise to abandon current spent nuclear fuel management programs or delay the opening of the first nuclear waste repository.
- Even with a successful separation and transmutation program, a monitored geologic repository would still be necessary because the process would be unlikely to provide perfect transmutation, in which

case there would be residual materials requiring long-term isolation from human populations and concentrations of human activity.

- Separation and transmutation technology might delay or eliminate the need for a second repository, but there are legislative and less expensive technical ways to increase the capacity of the first repository by an equivalent amount.

In the Fiscal Year 1999 Energy and Water Appropriation Act, Congress directed DOE to conduct an Accelerator Transmutation of Waste study and to prepare a plan for the development of this technology in Fiscal Year 1999. In October 1999, DOE submitted to Congress *A Roadmap for Developing Accelerator Transmutation of Waste (ATW) Technology* (DIRS 110625-DOE 1999, all). Key elements of the report include:

- The identification of technical issues requiring resolution
- The delineation of a 6-year science-based program to begin addressing resolution of technical issues
- If technical issues are resolved, a research and development plan for construction of a demonstration facility to become operational in 2035
- If research and development are successful, a production plan for transmutation of 79,000 metric tons (87,000 tons) of civilian waste over 90 years
- A listing of possible collaborative efforts with other countries
- The identification of institutional challenges of an Accelerator Transmutation of Waste program
- A discussion of possible benefits to other programs
- An estimate of the life-cycle costs for transmutation and processing of the currently projected inventory of civilian spent nuclear fuel

The report conclusions include the following:

- The implementation of Accelerator Transmutation of Waste technology will require years of additional research.
- The implementation of Accelerator Transmutation of Waste technology would require a significant investment in research and development funding.
- Accelerator Transmutation of Waste is technically feasible, but it would require billions of dollars and many decades to fully construct and operate a transmutation facility, and it would not eliminate the need for a repository.
- Complex institutional and public acceptance issues regarding the technology would have to be resolved.

A successful Accelerator Transmutation of Waste program would last approximately 117 years and would cost at least $281 billion dollars. Such a program could reduce the radioactivity of commercial waste by a factor of 10 to 100.

Since the October 1999 publication of the Accelerator Transmutation of Waste Roadmap, DOE's transmutation research and development program has undergone significant changes. It is currently managed as an Advanced Accelerator Applications program, with the goal of evaluating the technical feasibility of nuclear waste transmutation using a broader technology base than was covered by the earlier Roadmap. A general description of the modified program was presented in *The Advanced Accelerator Applications Program Plan* on March 30, 2001 (DIRS 156711-DOE 2001, all).

Among other aspects of the program, the plan discusses the proposed design and operation of an Accelerator Driven Test Facility as part of a research and development program that would evaluate combinations of critical and subcritical transmutation systems. These have the potential for utilizing the strengths of each transmutation technology in combination, the effectiveness of which is expected to be greater than either taken separately. A revised roadmap describing the program's new directions is currently being prepared.

The elimination or reduction of certain radionuclides in the disposal inventory could add flexibility to the design of the repository and reduce uncertainties about its performance. DOE will incorporate information from any future studies in its decisions during the preparation of a Mitigation Action Plan for this EIS and during the repository licensing process, if those became necessary.

9.1.4 MITIGATION ACTION PLAN

To minimize potential impacts from the Proposed Action (if the repository site was designated), DOE is evaluating the preparation of a Mitigation Action Plan containing specific commitments for mitigating adverse environmental impacts associated with the Proposed Action. The plan would describe specific actions DOE would take to implement mitigation commitments and would reflect available information about the course of action. DOE could revise this Plan as more specific and detailed information became available.

The Mitigation Action Plan would incorporate all practicable measures to avoid or minimize adverse environmental and human health impacts that could result from the implementation of the Proposed Action. The Plan would contain:

1. An introduction describing the basis, function, and organization of the Plan
2. A summary of the impacts to be mitigated
3. A statement of mitigation goals, objectives, and performance standards
4. A description of specific mitigation actions
5. A description of the Mitigation Action Plan monitoring and reporting system that DOE would implement to ensure that elements of the Plan were met

Precise mitigation measures cannot be identified at present. For example, transportation route selection decisions would affect the potential for impacts to areas of importance to Native Americans, to local communities, or to the general environment; repository or transportation corridor construction activities could reveal new cultural resource sites. DOE would consult with Native American tribes and local governments in developing the Mitigation Action Plan. If activities associated with the Proposed Action could affect specific sacred or ceremonial areas or resources or other areas of importance, DOE could develop procedures for controlled access as long as project integrity was not compromised.

DOE would prepare the Mitigation Action Plan in compliance with applicable regulations. The Plan would accompany any License Application to the Nuclear Regulatory Commission.

9.1.5 MONITORING

DOE would conduct the following monitoring activities during all phases of the project to ensure the implementation of the Proposed Action as described and to ensure mitigation of impacts:

- Continue the performance confirmation program which consists of tests, experiments, and analyses, during all phases of the repository project to evaluate the accuracy and adequacy of the information it used to determine with reasonable assurance that the repository would meet the performance objective for the period after permanent closure.
- Monitor groundwater quality, air emissions, and the repository workplace to ensure project worker safety and other aspects of project interaction with the natural and human environment during the construction, operation and monitoring, and closure phases of the project.
- Conduct cultural resources monitoring activities as appropriate before and during surface disturbance activities to identify and assess the potential for impacts to previously unidentified archaeological resources.
- Conduct monitoring and reporting activities to ensure the implementation and effectiveness of mitigation measures and to ensure in general the accomplishment of the elements of the Mitigation Action Plan.
- Monitor material emplaced in the repository starting with the first emplacement of waste packages and continuing through closure.
- After the completion of emplacement, continue to monitor and inspect waste packages and continue performance confirmation activities.
- After sealing the repository openings, conduct postclosure monitoring to ensure acceptable repository performance. Details of this program would be defined during processing of the license amendment for repository closure rather than now to take advantage of appropriate technology, including technology that might not be currently available.

9.2 Yucca Mountain Repository

This section discusses mitigation measures DOE has determined it would implement, or has identified for consideration, to reduce potential impacts from the construction, operation and monitoring, and eventual closure of the proposed repository.

9.2.1 LAND USE

The Yucca Mountain site is remote and is partly withdrawn for specific Federal uses. The permanent withdrawal of land for the repository would prevent public use of the withdrawn lands for other purposes.

Land Use Measures Under the Proposed Action

- Reclaim lands disturbed during the construction process and not required for permanent use by the repository and surface support facilities.

9.2.2 AIR QUALITY

Construction and operation activities such as vehicle movement, clearing, grading, rock pile maintenance, and excavating could generate substantial quantities of fugitive dust. Standard mitigation measures could reduce dust emissions from fugitive dust-generating activities at the Yucca Mountain site. Other dust-generating sources such as operation of the concrete batch plant and backfill preparation facilities would be comparatively small contributors. DOE expects concentrations of other criteria pollutants to be less than 1 percent of regulatory limits (see Chapter 4, Section 4.1.2). Activities that would generate other criteria pollutants include the operation of internal combustion engines in construction equipment, boiler operation, and similar devices, along with limited emissions of radionuclides.

Air Quality Measures Under the Proposed Action

- Reduce fugitive dust emissions using standard dust control measures routinely applied during construction projects including, for example, routine watering of unpaved surfaces; wet suppression for material storage, handling, and transfer operations; and wind fences to control windblown dust. The efficiency of these controls tends to vary depending on site characteristics, but it ranges from a 60- to 80-percent reduction in fugitive dust emissions (DIRS 103676-Cowherd, Muleski, and Kinsey 1988, p. 5-22).

- Reduce maximum fugitive dust concentrations with working controls such as scheduling construction operations to minimize concurrent generation by activities that were near each other (for example, conducting adjacent clearing and grading activities at different times).

- High-efficiency particulate air filters and modern facility design to minimize the potential for airborne contamination.

9.2.3 HYDROLOGY

This section describes potential mitigation measures for surface water and groundwater.

9.2.3.1 Surface Water

Potential impacts to surface water from the construction, operation and monitoring, and eventual closure of the proposed repository would fall into the following categories: (1) introduction of contaminants, (2) alteration of drainage either by changing infiltration and runoff rates or channel courses, and (3) flood hazards. Changes in infiltration and runoff rates could alter flow rates in channels, cause ponding, and increase erosion. DOE expects such impacts to be minimal (see Chapter 4, Section 4.1.3). Nevertheless, the mitigation of impacts could produce such benefits as erosion control and pollution prevention.

Flash floods could spread contamination from accidental spills. Design and operational controls could mitigate the potential for contamination of surface water from accidental releases of radiological or hazardous constituents. DOE's intent would be to respond rapidly with appropriate cleanup actions.

Surface-Water Measures Under the Proposed Action

- Minimize disturbance of surface areas and vegetation, thereby minimizing changes in surface-water flow and soil porosity that would change infiltration and runoff rates.

- Mitigate flood hazards by designing facilities to withstand or accommodate a 100-year flood, and by designing facilities that would manage radiological materials to withstand the calculated probable maximum flood.

- Minimize physical changes to drainage channels by building bridges or culverts where roadways would intersect areas of intermittent water flow. Use erosion and runoff control features such as proper placement of pipe, grading, and use of rip-rap at these intersections to enhance the effectiveness of the bridges or culverts.

- Maintain natural contours to the maximum extent feasible, stabilize slopes, and avoid unnecessary offroad vehicle travel to minimize erosion.

- In and near floodplains, follow reclamation guidelines (DIRS 102188-YMP 1995, all) for site clearance, topsoil salvage, erosion and runoff control, recontouring, revegetation, siting of roads, construction practices, and site maintenance.

- Implement best management practices, including training employees in the handling, storage, distribution, and use of hazardous materials, to provide practical prevention and control of potential contamination sources.

- Conduct fueling operations and store hazardous materials and other chemicals in bermed areas away from floodplains to decrease the probability of an inadvertent spill reaching the floodplains.

- Provide rapid response cleanup and remediation capability, techniques, procedures, and training for potential spills.

- Use sediment-trapping devices such as hay or straw bales, fabric fences, and devices to control water flow and discharge to trap sediments moved by runoff.

Surface-Water Measures Under Consideration

- Use physical controls such as secondary containment for fuel storage tanks to reduce the potential for releases to mingle with stormwater runoff.

9.2.3.2 Groundwater

Impacts to groundwater from the proposed repository could include introduction of contaminants and alteration of infiltration and runoff rates that could change the rate of recharge to the aquifer. Design and operational actions to reduce such impacts for the active life of the repository and the alteration of infiltration and runoff rates would be identical to those described above for surface-water impacts.

The purpose of proposing a monitored geologic repository is to provide a natural setting that, with engineered repository and waste package barriers, would provide long-term confinement and isolation of spent nuclear fuel and high-level radioactive waste. Two aspects of groundwater analysis—(1) the ability of the repository and the engineered barriers to keep waste packages isolated from groundwater over time, and (2) the extent to which groundwater could become contaminated with radionuclides from breached waste packages and transport radionuclides to places where human exposure could occur—are central elements in determining the potential for a proposed repository to succeed.

DOE's detailed study of the Yucca Mountain site has resulted in the inclusion of many engineered barrier elements to complement the site's natural characteristics to keep unsaturated zone groundwater from reaching and transporting radionuclides and, thereby, to reduce the long-term potential for impacts. The following summarizes the engineered barrier elements that would contribute to a reduction of the long-term potential for impacts from radionuclides isolated in a Yucca Mountain Repository.

Groundwater Measures Under the Proposed Action

- The Yucca Mountain site has several characteristics (as described in Chapter 3) that indicate a high potential for reducing possible long-term impacts from the disposal of spent nuclear fuel and high-level radioactive waste, including:
  - The Yucca Mountain vicinity is isolated from concentrations of human population and human activity and is likely to remain so.
  - The climate is arid and conducive to evapotranspiration, resulting in a relatively small volume of water that has the capability to move as groundwater within the unsaturated zone of the mountain.
  - The groundwater table is substantially below the level at which DOE would locate a repository, providing additional separation from materials emplaced in waste packages.
  - The sparsely populated hydrogeologic basin into which groundwater from Yucca Mountain flows is closed, providing a barrier to a general spread of radionuclides in the event waste packages were breached and radionuclides reached groundwater.
- Use performance confirmation measures to detect any departure from expected capability of the repository in confining and isolating waste.
- Recycle water collected in subsurface areas for use in dust suppression and other activities, to minimize water consumption.
- Implement measures to minimize the potential for water used during operations to interfere with waste isolation in the repository.
- Minimize surface disturbance, thereby minimizing changes in surface-water flow and soil porosity that could change infiltration and runoff rates.
- Use corrosion-resistant waste packages and other engineered barriers, such as drip shields, to prevent water intrusion.
- Monitor to detect and define unanticipated spills, releases, or similar events.
- Evaluate scenarios to minimize the potential for different heat levels to have a direct effect on corrosion rates and the integrity of containers, as well as on the hydrology, geochemistry, and stability of the drifts. High levels could indirectly affect general groundwater flow and the transport of radionuclides.
- Use stainless-steel-lined concrete basins that include leak detection systems, pool cleanup equipment, and transfer equipment capable of moving waste in the event of a leak, and that are designed to seismic standards to minimize the potential for leaks in fuel transfer and holding pools located inside surface facilities.
- Use drip shields to deflect water migrating downward through the unsaturated zone to waste emplacement areas.

9.2.4 BIOLOGICAL RESOURCES AND SOILS

Potential impacts to biological resources and soils from repository construction, operation and monitoring, and closure could result from land clearing, vehicle movement, materials placement,

trenching and excavation, and accidents. This section discusses the potential mitigation of impacts that could affect the desert tortoise and biological resources and soils in general.

9.2.4.1 Desert Tortoise

The desert tortoise is the only Federally protected species that resides on the site of the proposed repository (see Chapter 3, biology sections). Activities that could cause impacts to desert tortoises include site clearing, vehicle traffic, pond management, and taking of habitat. Since 1990, DOE has been conducting site characterization activities in accordance with Fish and Wildlife Service biological opinions on the potential for impacts to desert tortoises (DIRS 104618-Buchanan 1997, pp. 1 and 2). During these activities, five desert tortoises are known to have been killed by site characterization activities, all by vehicle traffic. A recent report (DIRS 103194-CRWMS M&O 1998, p. 9) indicates that 27 of 28 tortoise relocations were successful and that two nest relocations were also successful. The one unsuccessful relocation involved a tortoise that returned to the area of disturbance and became one of those killed by traffic.

DOE submitted to the U.S. Fish and Wildlife Service a biological assessment of the effects of construction, operation and monitoring, and closure of a geologic repository at Yucca Mountain. The U.S. Fish and Wildlife Service has produced a Final Biological Opinion on the effects of construction, operation and monitoring, and closure of a geologic repository at Yucca Mountain (see Appendix O). The Final Biological Opinion establishes conditions for repository construction, operation and monitoring, and eventual closure as well as for the remaining site activities prior to repository construction (if the site was approved). The Final Biological Opinion does not evaluate effects that could occur to the desert tortoise from the construction of transportation infrastructure and transportation of materials.

In its Final Biological Opinion, the U.S. Fish and Wildlife Service lists five reasonable and prudent measures to minimize impacts to the desert tortoise, and then lists 18 terms and conditions with which DOE must comply to implement the five measures. The Final Biological Opinion states reporting requirements upon the location of an injured or dead desert tortoise and conservation recommendations to minimize or avoid adverse effects on listed species or critical habitat. If the repository was authorized, DOE would observe and implement all terms and conditions, reporting requirements, and conservation recommendations that the U.S. Fish and Wildlife Service has established in its Final Biological Opinion to protect the desert tortoise. DOE expects to observe and implement all terms and conditions, reporting requirements, and conservation recommendations in any future biological opinions regarding the effects of transportation or other project activities on the desert tortoise or other listed species.

As discussed in Chapter 4, the proposed repository location is at the extreme northern edge of the range of the desert tortoise, and the population of tortoises at that location is small in relation to other portions of its range. No part of the repository location has been declared critical habitat for the desert tortoise.

Desert Tortoise Measures under the Proposed Action

DOE adopts all impact reduction measures and all terms and conditions established by the U.S. Fish and Wildlife Service to protect the desert tortoise.

The following text summarizes the five reasonable and prudent measures established in the U.S. Fish and Wildlife Service's Final Biological Opinion (see Appendix O), and identifies the terms and conditions that the Biological Opinion has set forth to implement each reasonable and prudent measure:

1. Minimize take of desert tortoises due to project-related activities and operation of heavy equipment

- A qualified biologist would conduct clearance surveys for tortoises before vegetation removal or soil disturbance of more than 0.02 square kilometer (5 acres) or when records indicated that tortoises could occur in the area to be disturbed. Project activity would be moved if there was an adjacent area free of tortoises on which the activity could be conducted. If no suitable site was available, the biologist would determine the site having the smallest impact on tortoises and their habitat.

- The biologist would conduct 100 percent coverage clearance surveys the day before or the day of surface-disturbing activity, during the tortoise activity season, and within 7 days before surface-disturbing activity during hibernation. If tortoises or eggs were found, they would be moved pursuant to U.S. Fish and Wildlife Service guidelines. Burrows would be conspicuously flagged and avoided by at least 9 meters (30 feet).

- Unavoidable burrows would be inspected. If unoccupied, burrows would be collapsed to prevent tortoise entry. If tortoises or eggs were present, they would be excavated by hand and moved.

- If removed from a burrow, a tortoise would be placed in the shade of a shrub or an existing, similar, unoccupied burrow. A tortoise moved when in hibernation, estivation, or brumination (dormant states due to heat or cold) would be placed in an adequate unoccupied or constructed burrow.

- Project activities that could endanger a tortoise would cease if a tortoise was found on a project site and would not resume until after the tortoise moved or was moved out of danger by the biologist.

- A desert tortoise biologist or environmental monitor would be at the site during all phases of construction to ensure compliance with the Biological Opinion and to protect tortoises from harm. The environmental monitor would be responsible for: (1) enforcing the litter-control program; (2) ensuring that tortoise-proof fences were maintained; (3) ensuring that tortoise habitat disturbance was restricted to authorized areas; (4) ensuring storage of all equipment and materials within construction zones or previously disturbed areas; (5) ensuring that all vehicles used existing graded or paved roads or stayed within construction zones; (6) ensuring inspection of open trenches and other excavations; (7) ensuring that speed limits were observed; and (8) ensuring compliance with all terms and conditions of the Biological Opinion. Environmental monitors would not be authorized to handle tortoises.

- Vehicles would not be driven off existing roads in nonemergency situations unless authorized by DOE. Vehicle paths would be cleared of tortoises pursuant to terms of the Biological Opinion.

- Vehicles would be driven at speeds within posted limits on existing roads, and would not exceed 40 kilometers (25 miles) per hour on unposted roads.

- DOE would continue to present a tortoise education program to all employees on the project site and would address specific issues identified in the Biological Opinion. The education program would include definition of “take” and specification, actions that must be avoided, procedures for handling tortoises found on roads, and identification of personnel authorized to handle or otherwise capture and relocate tortoises.

- Marking or telemetry of tortoises would not be allowed.

2. Minimize entrapment of tortoises in open trenches.

    - During tortoise active season, all open trenches with slopes steeper than 0.3 meter (1 foot) rise per 0.9 meter (3 feet) of length would be fenced off, covered, or constructed with escape ramps if they were not immediately backfilled.

    - Open trenches would be inspected for entrapped animals immediately prior to backfilling.

    - If a tortoise was discovered in a trench, all activities associated with the trench would cease until a qualified biologist had removed the tortoise.

3. Minimize predation on tortoises by ravens drawn to the project area.

    - DOE would implement a litter control program that would include the use of covered, raven-proof trash receptacles; disposal of edible trash in trash receptacles after each workday; and disposal of trash in a sanitary landfill. Materials placed in a landfill would be covered often enough to prevent ravens and other predators from feeding in the area.

4. Minimize destruction of tortoise habitat due to project activities

    - DOE would revegetate areas no longer required by the project in accordance with existing procedures and pursuant to site-specific rehabilitation plans prepared in accordance with the Biological Opinion.

5. Ensure compliance with reasonable and prudent measures, terms and conditions, reporting requirements, and reinitiation requirements in the Biological Opinion.

    - DOE personnel would have to acquire appropriate State permits from the Nevada Division of Wildlife prior to handling a desert tortoise, carcass, or egg.

    - DOE would designate a field representative (who could also serve as the environmental monitor), who would be responsible for overseeing compliance with protective stipulations and for coordinating compliance with the terms and conditions of the Biological Opinion, and who would have authority to halt construction equipment activities that could be in violation of the protective stipulations.

    - DOE would keep an up-to-date log of all actions related to the consultation, including acreage affected, habitat rehabilitation actions completed, number of desert tortoises taken and by what means (injured, killed, captured and displaced, or found in trenches or pits). The information would be provided to the U.S. Fish and Wildlife Service Las Vegas Office in the form of an annual report on February 28 of each year during which activities addressed by the Biological Opinion occurred.

9.2.4.2 General Biological Resources and Soils

Impacts to biological resources at the Yucca Mountain site could include habitat fragmentation, loss of individual members of different species, and encroachment of noxious weeds.

Potential soil impacts or concerns related to the proposed repository can be categorized as (1) increased soil erosion rates, (2) slow recovery rate of disturbed soils in the Yucca Mountain environment, and (3) introduction of contaminants. Erosion could result in the loss of the thin topsoil from the disturbed

areas, which could affect long-term recovery, be a threat to structures in the region, and result in increased depositions downhill.

General Biological Resources and Soils Measures Under the Proposed Action

- Use the measures described in Section 9.2.2 to control erosion, dust, and particulate matter and therefore to lessen the consequences for biological resources and soils from repository construction, operation and monitoring, and closure.

- Use dust suppression measures such as application of water or environmentally sensitive methods to minimize wind and other erosion and aid recovery on disturbed areas.

- Conduct preconstruction surveys in floodplains to ensure that work would not affect important biological resources and to determine the reclamation potential of sites.

- Consider measures to relocate or avoid sensitive species in floodplains.

- If construction could threaten important biological resources in floodplains, and modification or relocation of the roads and rail line would not be reasonable, develop additional mitigation.

General Biological Resources and Soils Measures Under Consideration

- Align and locate facilities, roadways, cleared areas, laydown areas, and similar construction activities to minimize fragmentation of habitat potentially affected by the proposed project.

- Mitigate potential soil erosion by minimizing areas of surface disturbance and using engineering practices to stabilize disturbed areas. These practices could include such measures as stormwater runoff control through the use of holding ponds, baffles, and other devices and the compacting of disturbed ground, relocated soil, or excavated material in places outside desert tortoise habitat.

- Mitigate the introduction of contaminants to soils, using methods similar to those described for surface-water impacts (see Section 9.2.3.1).

- To aid recovery, strip and stockpile topsoil from disturbed areas (excavated rock pile, etc.). When the disturbed areas are no longer needed, spread the topsoil over the areas and reseed the soil to improve the success of vegetation reestablishment and prevent encroachment of invasive species.

- Provide escape ramps from ponds and basins.

9.2.5 CULTURAL RESOURCES

Land clearing, excavation, and construction activities have the potential to disturb or cause the relocation of cultural artifacts. The operation of industrial facilities can degrade the value of traditional sites or uses. In addition, human activity in project areas causes concern that members of the workforce could affect cultural resource sites, especially those at buried locations or with artifacts.

Actions that DOE would take to mitigate adverse impacts to cultural resources at Yucca Mountain include those required by law or regulation and those that DOE determined the project would include to reduce such impacts. In some cases, precise mitigation measures cannot be identified due to the limited nature of the data (for example, construction activities could reveal previously unidentified sites). To address these cases, programmatic mitigation measures that comply with historic preservation laws and regulations are in place to ensure that DOE would implement appropriate measures following the identification and evaluation of important cultural resources.

The *Programmatic Agreement Between the United States Department of Energy and the Advisory Council on Historic Preservation for the Nuclear Waste Deep Geologic Repository Program, Yucca Mountain, Nevada* (DIRS 104558-DOE 1988, all) contains the requirements and general procedures for the mitigation of adverse effects at important archaeological and historic sites in the Yucca Mountain region during site characterization. DOE would work to review and update that agreement to establish requirements and procedures for mitigation of any adverse effects at important archaeological and historic sites during construction, operation and monitoring, and closure of the proposed repository in the event the repository was authorized.

The *Research Design and Data Recovery Plan for the Yucca Mountain Project* (DIRS 103196-DOE 1990, all) outlines more detailed approaches and procedures for implementing the mitigation of impacts to archaeological sites. Along with other topics, that document provides specific guidelines for determining the rationale, methods, analytical requirements, and logistics for archaeological mitigation measures at Yucca Mountain. In addition, the Department would consult with affected Native American tribes and organizations to ensure that repository activities avoided or minimized adverse impacts to resources or places that are important to American Indians.

Cultural Resources Measures Under the Proposed Action

- Ensure that onsite employees complete cultural resource sensitivity and protection training to reduce the potential for intentional or accidental harm to sites or artifacts. The training could include descriptions of the importance of different cultural resource types, procedures to follow if resources were encountered in the field, and employment-related and legal penalties for not following the requirements.

- Continue to use the Yucca Mountain Project Native American Interaction Program, which has been in existence since 1985, to promote a government-to-government relationship with Native American tribes and concentrate on the continued protection of important cultural resources. A considerable part of this effort could continue to be directed at protecting these resources and mitigating adverse effects to the fullest extent possible. Historically, as part of this program, members of Native American tribes have made recommendations to DOE about potential adverse effects, mitigation procedures that involve required consultation with tribal governments, and direct involvement of Native Americans in proposed project activities that could affect cultural resources or values (DIRS 102043-AIWS 1998, pp. 1-1, 2-3, and B-1 *et seq.*). Examples of suggested mitigations include incorporating the assistance of Native American people, continued protection of archaeological sites, funding Native American studies on impacts to natural resources and impacts from transportation (DIRS 102043-AIWS 1998, pp. 4-8 to 4-12).

- Conduct preconstruction surveys to ensure that work would not affect important archaeological resources and to determine the research potential of sites.

- If construction could threaten important archaeological resources, and modification or relocation of roads or rail lines would not be reasonable, develop additional mitigation measures.

9.2.6 OCCUPATIONAL HEALTH AND PUBLIC SAFETY

There would be a potential for repository workers to be exposed to radiation during the operation and monitoring and closure phases of repository activities or to be injured or killed as a result of hazards present in the industrial workplace (Chapter 4, Sections 4.1.7 and 4.1.8; Chapter 8, Section 8.2.7).

Erionite and cristobalite are hazardous materials that occur naturally in the Yucca Mountain subsurface. Erionite occurs in strata at varying depths below the planned level of the repository. DOE is mapping these strata as part of a general approach that emphasizes avoidance of erionite. If erionite was

encountered during drilling, DOE would shut down the affected portion of its operation until it could put proper controls in place.

Cristobalite, which occurs generally in the subsurface rock structure, could be released during excavation operations or in fugitive dust from the excavated rock pile. There would be a potential for cristobalite to be an inhalation hazard to workers. Implementing specific health and safety plans to prevent worker exposure would minimize risks. Chapter 4, Section 4.1.7, discusses erionite and cristobalite.

After closure, there would be potential for human intrusion that could result in release of radioactive materials.

Occupational and Public Health and Safety Measures Under the Proposed Action

- Avoid erionite-bearing strata where practicable during repository construction and drift development.
- If drilling encountered erionite, close operations in potentially affected areas until proper controls were in place.
- Use high-efficiency particulate air filters or similar controls if drilling occurred in an area where there is potential for encountering erionite.
- Design repository construction procedures to reduce the risk of worker inhalation of cristobalite or erionite.
- Specify features of ventilation systems and other underground equipment to ensure the elimination of opportunities for occupational exposure to health and safety hazards.
- Use ventilation, planned transfer of cristobalite from work areas, and scrubbing of in-place dust to minimize exposure. Use monitoring devices and respirators as appropriate.
- Use ventilation to keep radon levels low in subsurface areas. Use higher ventilation rates and shorter air travel paths to reduce worker exposure to radon.
- Unload, handle, and package spent nuclear fuel and high-level radioactive waste remotely in hot cells or under water.
- Provide appropriate shielding during operations and during shipping and handling of packages when personnel would be present and could be exposed.
- Minimize to the extent practicable the amount of time workers would spend in the subsurface environment.
- Design task procedures to reduce the potential for accidents.
- Implement health and safety procedures and administrative controls to minimize risks to construction and operations workers.
- Design task procedures to reduce the potential for accidents that could lead to radioactivity releases in the workplace environment.

9.2.7 AESTHETICS

Construction, operation and monitoring, and closure of the proposed repository would require the lighting of certain areas of the repository at night. While the repository site is remote, and there are existing sources of nighttime light in the region, nighttime darkness is a valued component of the solitude experience sought by many individuals. Nighttime darkness enhances astronomy and stargazing activities and is one of the important scenic resources of Death Valley National Park.

Aesthetics Measures Under the Proposed Action

- Use exterior lighting only where needed to accomplish facility tasks.
- Limit the height of exterior lighting units, focusing more light on the ground surface and reducing the effects of night lighting on surrounding areas. This limitation would enable the use of reduced wattage output lamps, but could require the use of additional lighting units to obtain the same amount of ground coverage.
- Use shielded or directional lighting to limit the effects of the lighting to areas where it is needed.

Aesthetics Measures Under Consideration

- Orient ventilation system stacks and support structures and use re-contouring and natural vegetation to reduce facility visibility.

9.2.8 UTILITIES, ENERGY, AND MATERIALS

A monitored repository at Yucca Mountain would require a range of utility services, energy to power a variety of activities, and a number of diverse materials. DOE intends to promote efficiency in the use of utilities, energy, and materials.

Utility, Energy, and Materials Measures Under the Proposed Action

- Implement procedures and equipment that would minimize the use of utility services, energy, and materials.

9.2.9 MANAGEMENT OF REPOSITORY-GENERATED WASTE AND HAZARDOUS MATERIALS

As part of the repository design, DOE would institute a waste minimization program similar to the waste minimization and pollution prevention awareness plan successfully implemented during site characterization activities to minimize quantities of generated waste and to prevent pollution (DIRS 103203-YMP 1997, all). In addition, DOE would consider innovations to augment the existing program. The Department could keep the size of the Restricted (for radiological control) Area as small as possible, and it could implement programs to ensure that construction and operation activities used, as practicable, smaller quantities of products such as solvents and cleaners. The design of the proposed repository would incorporate pollution prevention measures and would provide cradle-to-grave waste management, as DOE provided during site characterization.

Waste and Hazardous Materials Measures Under the Proposed Action

- Recycle wastewater to reduce the amount of water needed for repository facilities and the amount of wastewater that could require disposal (DIRS 100248-CRWMS M&O 1997, p. 14).
- Use practical, state-of-the-art decontamination techniques such as pelletized solid carbon dioxide blasting that would reduce waste generation in comparison with other techniques (DIRS 100248-CRWMS M&O 1997, pp. 9-13 and 9-14).

- Institute preventive maintenance and inventory management programs to minimize waste from breakdowns and overstocking (DIRS 104508-CRWMS M&O 1999, p. 55).

- Whenever practicable, recycle nonradioactive materials such as paper, plastic, glass, nonferrous metals, steel, fluorescent bulbs, shipping containers, oils, and lubricants rather than dispose of them (DIRS 104508-CRWMS M&O 1999, pp. 62 and 70). Encourage the reuse of materials and the use of recycled materials.

- Avoid use of hazardous materials where feasible.

Waste and Hazardous Materials Measures Under Consideration

- When protective of the environment and cost effective, recycle dual-purpose canisters.

- Recycle solar panels if cost-effective and environmentally sound recycling options are available.

9.2.10 LONG-TERM REPOSITORY PERFORMANCE

DOE proposes a repository at Yucca Mountain to provide for permanent disposal of spent nuclear fuel and high-level radioactive waste. DOE's proposal includes a natural geologic setting that, with engineered repository and waste package barriers, would provide long-term isolation of spent nuclear fuel and high-level radioactive waste. In its design process, DOE is considering many features and approaches to contain and isolate the materials it proposes to place in the repository.

DOE's detailed study of the Yucca Mountain site and vicinity has resulted in the evaluation of three categories of potential measures: Barriers to limit the release and transport of radionuclides, measures to control heat and moisture in the confined environment of the repository, and measures to improve operational efficiency or safety. Each of these measures has the potential to complement the site's natural characteristics. These measures are conceptual in nature. The following sections summarize design features that could contribute to a reduction of the long-term potential for impacts from radionuclides isolated in a Yucca Mountain Repository. Long-term performance measures are discussed in more detail in Appendix E.

Long-Term Performance Measures Under the Proposed Action

DOE has designed an engineered barrier system that would complement the geologic and hydrologic properties of Yucca Mountain to isolate radionuclides in spent nuclear fuel and high-level radioactive waste from accessible portions of the environment. Design features that are part of the Proposed Action are presented below. The repository flexible design described in Chapter 2 of this EIS can be operated in a range of operating modes, from higher- to lower-temperature. Measures that are unique to only one operating mode are so noted.

- Use two-layer waste packages designed to remain intact for thousands of years (at a minimum), with layers that would fail only from different mechanisms and at different rates.

- Encapsulate spent nuclear fuel (normally in zirconium-alloy cladding) and immobilize high-level radioactive waste (normally in borosilicate glass or ceramic matrices) in the waste packages.

- Use nickel-chromium alloy (Alloy-22) emplacement pallets to hold waste packages off the floors of emplacement drifts.

- Use heat generated from the decay of radioactive material to heat the surrounding rock to drive water and gas away from the emplaced waste packages (higher-temperature operating mode).

- Use drip shields to provide a partial barrier to divert infiltrating water away from waste packages in an emplacement drift.

- Ground support options – Placing an engineered system into repository drifts to ensure drift stability before closure could both enhance safety during emplacement and potential retrieval and improve long-term repository performance by reducing or delaying damage to canisters from rockfall (damaged areas are locations for enhanced corrosion even if the canister is not breached by the rockfall).

- Increase the spacing between waste packages or drifts, or reduce the size of waste packages and maintain spacing to potentially reduce uncertainties regarding elevated temperature of the host rock and reduce waste package material corrosion rates (lower-temperature operating mode).

- Waste package spacing and drift spacing – Emplacing waste packages nearly end-to-end [that is, with a 0.1-meter (0.3-foot)-gap] with no consideration of individual waste package characteristics would provide a more intense and uniform heat source along the length of emplacement, requiring an increase in emplacement drift spacing and, potentially, continuous ventilation of emplacement drifts, but also would keep emplacement drifts hot and dry for a longer period, decrease the amount of water that could contact waste packages, and reduce the number of emplacement drifts needed for waste emplacement (higher-temperature operating mode).

- Use preemplacement aging and blending of spent nuclear fuel and high-level radioactive waste to provide thermal performance benefits. Aging would reduce the total thermal energy that the repository must accommodate, and blending would reduce the variability in the distribution of the thermal energy in the repository drifts. Potential benefits would be improved rock stability and retardation of waste package degradation (lower-temperature operating mode).

- Continuous preclosure ventilation – Continuous ventilation in the emplacement drifts before repository closure would reduce rock wall and air temperatures and remove moisture to reduce corrosion rates and increase the stability of the ground support system.

- Timing of repository closure – Extending the period before final closure, together with a maintenance program to accommodate an extended long-term repository service life and ground support components designed and maintained for a service life of up to 300 years, would allow for reduction of waste package heat output after closure, extended monitoring before closure, and an extended retrieval period for the waste (lower-temperature operating mode).

Long-Term Performance Measures Under Consideration

The design features listed below are being considered, though some are not currently under active consideration. These features are organized by their design purpose, either to limit release and transport of radionuclides, control heat and moisture in the repository environment, or support operational considerations.

Barriers to Limit Release and Transport of Radionuclides. The most direct method to provide the long-term isolation of contaminants is to use structures and techniques that have the potential to inhibit directly the release of contaminants from waste packages or to reduce the likelihood of the transport of released contaminants from the repository. DOE is considering a range of barrier measures that could enhance resistance to corrosion, delay or reduce water transport, retard radionuclide movement and release rates, and reduce the potential for damage to canisters. The Department will continue to evaluate the potential benefits and consequences of these measures together with their compatibility with overall repository system design.

- Ceramic coatings on the exterior of the waste package – Could increase waste package life and repository waste isolation performance by reducing corrosion of the waste package surface and delaying the release of radionuclides.

- Diffusive barrier under waste packages – Loose, dry, granular material placed in the space between each waste package and the bottom of the emplacement drift to form a restrictive barrier to seepage, potentially slowing fluid and radionuclide movement to the natural environment.

- Getter under waste package – Placing a fine-grained material [either phosphate rock (apatite) or iron oxide (hematite, geothite, etc.] with an affinity for sorption of radionuclides in the recess below waste packages prior to waste emplacement could improve long-term waste isolation through retardation of radionuclide movement from the repository drifts.

- Canistered assemblies and waste-specific disposal containers – Placing spent fuel assemblies in canisters at the Waste Handling Building before inserting them into waste packages could provide an additional barrier and further limit mobilization of radionuclides if the waste package was breached.

- Additives and fillers – Placing materials (for example, oxides of iron and aluminum) into waste packages (in addition to those normally required for the basket material) to fill the basket and waste form void spaces could improve both the long-term repository performance (by retarding of release of radionuclides to the groundwater) and the long-term *criticality control*.

Measures to Control Heat and Moisture in the Repository Environment. Long-term influence over heat and moisture in the repository environment could increase the ability of the waste packages to isolate waste. DOE has evaluated measures that have the potential to control temperature and humidity levels in the repository to reduce corrosion rates, increase structural and support system stability, and increase the capability to retain released radionuclides in the repository. The Department will continue to examine the potential for enhancements in repository performance offered by these measures, other consequences of implementing them, and their compatibility with overall repository system design. DOE is considering the items listed below:

- Tailored waste package spatial distribution – Tailoring spatial distribution of the waste packages within the repository block according to waste package heat production, or the tendency of radionuclides in different packages to travel, resulting in a more uniform temperature across the repository. This would improve the performance of waste packages by delaying and reducing contact of water and/or increasing sorption of released radionuclides by zeolites in the unsaturated zone, thereby potentially improving repository waste isolation performance.

- Continuous postclosure ventilation design – Continuous ventilation of the emplacement drifts during the postclosure period could increase removal of moisture from air around the waste packages for a period of time (though moisture would eventually reestablish itself), and it could improve performance by retarding waste package corrosion.

- Drift diameter – A smaller diameter drift would be more stable (less rockfall potential), could reduce seepage into the drifts, and could reduce the need for ground support systems, while a larger diameter drift would allow for other modes of emplacement, such as horizontal or vertical borehole emplacement.

- *Near-field* rock treatment during construction – Filling cracks in a portion of the rock above each emplacement drift with grout to reduce or retard water seepage into the drifts after closure of the repository.

- Surface modification (alluvium) – Covering the surface of Yucca Mountain above the repository footprint with alluvium (soil) could decrease the net infiltration of precipitation water into the repository.

- Surface modification (drainage) – Removing the thin alluvium layer over the footprint of the repository would promote rapid runoff of surface water, potentially reducing infiltration from the top and improving long-term isolation of the waste.

Repository Designs to Support Operational Considerations. Including elements in the design that would enhance the repository's operational capabilities could improve access to waste packages after their emplacement, increase access for conducting performance confirmation, inspection, and maintenance activities, ease any effort to augment the repository system with later-developed materials or processes, and facilitate retrieval of waste packages if retrieval became necessary. DOE is considering measures that could provide additional shielding for personnel, increase usable space in drifts, increase opportunities for monitoring, and reduce the potential for moisture to contact waste packages. The Department will continue to assess the potential for design modifications to assist operational activities within the context of overall repository system design. DOE is considering the following potential design modification measures:

- Rod consolidation – Rod consolidation would involve bringing fuel rods into close contact with one another, allowing the capacity of waste packages to be increased and/or the size of waste packages to be reduced, potentially reducing the size or number of waste packages and, if consolidation were accomplished at the reactor sites, possibly reducing waste transportation shipments.

- Waste package self shielding – Adding a shielding material on the outside of waste packages would reduce the radiation in the drifts to levels such that personnel access would be possible.

- Repository horizon – A two-level repository would increase repository capacity without moving out of the characterized area. It would increase thermal load to reduce the amount of water that could come in contact with waste packages; add flexibility in emplacing waste packages on the lower level, which could be shielded from moisture infiltration by the upper level; and potentially facilitate retrieval due to the ability to operate two independent retrieval operations at the same time.

9.3 Transportation

This section discusses mitigation measures DOE is required to implement, has determined to implement, or has identified for consideration, to reduce potential impacts from the national transportation of spent nuclear fuel and high-level radioactive waste. These measures address impacts from the possible construction of a branch rail line or an intermodal transfer station in Nevada; construction of other transportation routes; upgrading of existing Nevada highways to accommodate heavy-haul vehicles; transportation of spent nuclear fuel and high-level radioactive waste from existing storage sites to the proposed repository; and fabrication of casks and canisters.

9.3.1 LAND USE

Mitigation measures could address three types of potential land-use impacts resulting from the construction and operation of a rail line or an intermodal transfer station: (1) impacts to publicly used lands such as grazing allotments, (2) direct and indirect land loss, and (3) displacement of capital improvements. Mitigation would not necessarily be associated with the potential selection of a route for heavy-haul trucks, which would follow existing rights-of-way and would require little additional land disturbance.

Land Use Measures Under the Proposed Action

- Ensure that construction activities were consistent with best management practices, by:
  - Ensuring that the location selection and final route alignment for a branch rail line or location selection for an intermodal transfer station, in consultation with parties controlling the surrounding lands, consider (1) the minimum impacts to private lands, capital improvements, floodplains or wetlands, areas containing cultural resources, or other environmentally sensitive areas, and (2) indirect loss of land or loss of use of land (the division of property or limitation of access) such as the use of grazing allotments.
  - Minimizing the size and number of easements.
  - During the rail construction phase, locating construction camps and staging areas along the rail line in consultation with parties controlling the surrounding lands.
  - Reclaiming disturbed areas outside the permanent right-of-way as soon as practicable after completion of construction.

Land Use Measures Under Consideration

- For grazed lands (lands grazed on by cattle), provide access across routes via underpasses, revegetate disturbed land, and aid in water provision (if access to water sources by herds is impeded).
- Coordinate DOE transportation schedules with U.S. Air Force training schedules to ensure that transportation of spent nuclear fuel and high-level radioactive waste through Air Force-controlled lands to a Yucca Mountain Repository would not result in safety-related restrictions being imposed on Air Force training activities.
- Implement additional rail realignments where feasible to avoid safety-imposed restrictions on U.S. Air Force use of lands the Air Force controls and uses for training purposes.
- If DOE selected the Bonnie Claire Alternate to the Caliente or Carlin rail corridor as part of its transportation route to Yucca Mountain, evaluate the potential for realignment of this alternate to reduce or eliminate the taking of land from the Timbisha Shoshone Trust Lands.
- Initiate no construction that would cross any presently designated wilderness study area unless that study area had been released from interim status by the State Director of the Bureau of Land Management as nonsuitable for wilderness or Congress has acted to remove the Wilderness Study Area designation.

9.3.2 AIR QUALITY

If DOE selected the Valley Modified rail corridor, mitigation measures could be needed to reduce fugitive dust emissions from rail line construction and carbon monoxide emissions from operations in the Las Vegas Valley nonattainment area. As described in Chapter 6, Section 6.3.2.2.5, fugitive dust emissions during the construction phase could be above the General Conformity Rule minimal levels for particulates. Vehicles used to transport workers and trains used to transport materials would generate criteria pollutants. States could place requirements for control of emissions of volatile organic compounds and nitrous oxide on facilities that manufacture containers and casks.

Air Quality Measures Under Consideration

- Employ two construction crews at half pace from opposite ends if the Valley Modified rail line was selected. Because only approximately 50 percent of the corridor length is in the Las Vegas Valley air basin, emission rates would be reduced to levels at or below General Conformity thresholds.

- Use buses to transport workers, reducing nitrogen oxide and hydrocarbon emissions.

- Reduce fugitive dust emissions using standard dust control measures routinely applied during construction projects including, for example, routine watering of unpaved surfaces; wet suppression for material storage, handling, and transfer operations; and wind fences to control windblown dust. The efficiency of these controls tends to vary depending on site characteristics, but it ranges from a 60- to 80-percent reduction in fugitive dust emissions (DIRS 103676-Cowherd, Muleski, and Kinsey 1988, p. 5-22).

- Reduce maximum fugitive dust concentrations with working controls such as scheduling construction operations to minimize concurrent generation by activities that were near each other (for example, conducting adjacent clearing and grading activities at different times).

9.3.3 HYDROLOGY

This section describes potential mitigation actions for both surface water and groundwater.

9.3.3.1 Surface Water

Three categories of potential impacts to surface water from the construction and operation of a Nevada transportation route are (1) the introduction of contaminants, (2) the alteration of drainage patterns or runoff rates, and (3) flood hazards. The spread of contamination by surface water could result in adverse impacts to plants and animals or to human health in the immediate area. It could also result in the recharge of contaminated water to groundwater. DOE's intent is to respond rapidly to such spills with appropriate cleanup actions.

Surface-Water Measures Under the Proposed Action

- Minimize disturbance of surface areas and vegetation, thereby minimizing changes in surface-water flow and soil porosity that would change infiltration and runoff rates.

- Mitigate flood hazards by designing facilities to withstand or accommodate a 100-year flood.

- Minimize the potential for contamination spread or other physical impacts to surface water by avoiding spills in unconfined areas and areas subject to flash floods, where practicable, and by locating the alignment of a branch rail line or heavy-haul road to avoid floodplains and surface waters, including wetlands, springs, and riparian areas, when possible, and to minimize any potential impacts to these features.

- Maintain natural contours to the maximum extent feasible, stabilize slopes, and avoid unnecessary offroad vehicle travel to minimize erosion.

- Minimize physical changes to drainage channels by building bridges or culverts where roadways would intersect areas of intermittent water flow. Use erosion control features such as proper placement of pipe, revegetation, and use of erosion control at these intersections where practicable to enhance the effectiveness of the bridges or culverts.

- Use physical controls such as secondary containment for fuel storage tanks to reduce the potential for releases to mingle with stormwater runoff.

- In and near floodplains, follow reclamation guidelines (DIRS 102188-YMP 1995, all) for site clearance, topsoil salvage, erosion and runoff control, recontouring, revegetation, siting of roads, construction practices, and site maintenance.

- Implement best management practices including training employees in the handling, storage, distribution, and use of hazardous materials to provide practical prevention and control of potential contamination sources.

- Conduct fueling operations and store hazardous materials and other chemicals in bermed areas away from floodplains to decrease the probability of an inadvertent spill reaching the floodplains.

- Provide rapid response cleanup and remediation capability, techniques, procedures, and training for potential spills.

Surface-Water Measures Under Consideration

- Designate bermed or contained sites outside areas subject to flash flooding for fueling and chemical handling to minimize the potential for contamination spreading if spills occurred.

9.3.3.2 Groundwater

Potential transportation-related impacts to groundwater would be most likely to occur from construction activities associated with a potential Nevada transportation route and could include introduction of contaminants and alteration of infiltration and runoff rates that could change the rate of recharge to the aquifer. Design and operational actions to reduce impacts would be identical to those described above for surface-water impacts.

Groundwater Measures Under the Proposed Action

- Implement best management practices, such as training employees in the handling, storage, distribution, and use of hazardous materials, to provide practical prevention and control of potential contamination sources.

- Minimize surface disturbance, thereby minimizing changes in surface-water flow and soil porosity that could change infiltration and runoff rates.

Groundwater Measures Under Consideration

- Place construction wells only in undesignated basins. (A Designated Groundwater Basin is one in which the quantity of appropriated water approaches or exceeds the perennial yield as *determined* by the Nevada State Engineer.)

- Employ water-use minimization and recycling techniques to reduce water consumption.

9.3.4 BIOLOGICAL RESOURCES AND SOILS

9.3.4.1 Desert Tortoise

The desert tortoise is a Federally protected species that resides at or along the candidate rail corridors, intermodal transfer station locations, and routes for legal-weight and heavy-haul trucks in Nevada (see Chapter 6, Sections 6.3.1, 6.3.2.1, and 6.3.3.1). Activities that could cause impacts to desert tortoises include site clearing, vehicle traffic, pond management, and taking of habitat.

DOE has been conducting site characterization activities in accordance with Fish and Wildlife Service biological opinions on the potential for impacts to desert tortoises (DIRS 104618-Buchanan 1997, pages 1 and 2). During these activities, five desert tortoises are known to have been killed by site characterization activities, all by vehicle traffic. A recent report (DIRS 103194-CRWMS M&O 1998, page 9) indicates that 27 of 28 individual tortoise relocations were successful and that two nest relocations were also successful. The one unsuccessful relocation involved a tortoise that returned to the area of disturbance and became one of the five killed by traffic.

If the proposed project proceeded, the U.S. Fish and Wildlife Service would establish measures, terms, and conditions for transportation activities that DOE would have to observe to protect the desert tortoise. DOE would implement terms and conditions established in any future biological opinions regarding the effects of repository-related transportation activities on the desert tortoise. As discussed in Chapter 6, areas that would be affected by transportation activities are at the extreme northern edge of the range of the desert tortoise, and the population of tortoises in these areas is low in relation to other portions of its range. No part of any of the candidate transportation routes has been declared critical habitat for the desert tortoise.

The final biological opinion on site characterization (DIRS 104618-Buchanan 1997, pp. 19 to 25) identified the following actions as requirements that DOE would need to implement to minimize impacts on desert tortoises. The U.S. Fish and Wildlife Service could establish similar conditions as prerequisites for transportation activities associated with the proposed project.

- Alignment and final siting of facilities, construction roadways, cleared areas, laydown areas, and similar elements of construction activity could avoid sensitive areas, lessen the likelihood of entrapment of tortoises, and minimize the fragmentation of known desert tortoise habitat.

- Measures to control erosion, dust, and particulate matter would lessen consequences of repository construction, operation and monitoring, and closure for desert tortoises. Similarly, approaches to minimize soil compaction and crushing of vegetation would lessen consequences for desert tortoises.

- Clearance surveys for desert tortoises before vegetation removal or soil disturbances of more than about 2 hectares (5 acres).

- Removal of tortoises or tortoise eggs found in areas to be disturbed, and tortoises in immediate danger along roads or near ongoing activities to safe nearby locations, with project activity ceasing until removal occurred.

- Prohibitions against driving vehicles off existing roads in nonemergency situations unless authorized. All workers at Yucca Mountain would participate in a required tortoise education program.

- A litter-control program that would include the use of covered, raven-proof trash receptacles, disposal of edible trash in trash receptacles following the end of each workday, and disposal of trash in a designated sanitary landfill.

- Revegetation of project areas no longer required.

- Construction and maintenance of tortoise-proof fencing to lessen the potential for endangerment to desert tortoises from project-related activities.

- Placement of escape ramps in trenches and inspection of trenches before filling.

Desert Tortoise Measures Under the Proposed Action

If a consultation process resulted from a determination that construction or operation of a transportation corridor associated with the proposed repository could affect threatened or endangered species or their habitat, DOE will adopt all reasonable and prudent measures to protect the desert tortoise or other species that could be stated in future biological opinions on transportation corridors.

The following text discusses potential transportation-related measures DOE has identified for the protection of the desert tortoise based on determinations the U.S. Fish and Wildlife Service made for site characterization.

- Align and locate facilities, roadways, and cleared areas and place appropriate signs to lessen the likelihood of trapping tortoises and to minimize habitat fragmentation.
- Minimize soil compaction and vegetation crushing.
- Move desert tortoises or desert tortoise eggs from areas to be disturbed, from roadways, and from proximity to ongoing activities to safe nearby locations; stop project activity until completion of these actions.
- Require authorization for nonemergency offroad vehicle travel.
- Ensure that all workers on the Yucca Mountain Project participate in a tortoise education program.
- Establish a litter-control program that would include the use of covered, raven-proof trash receptacles, disposal of edible trash in trash receptacles at the end of each workday, and disposal of trash in a designated sanitary landfill located away from desert tortoise habitat in order to avoid attracting potential predators.
- Revegetate project areas no longer required for the Proposed Action.
- Post road signs to remind drivers of the presence of desert tortoises and other animals, and enforce speed limits.
- Construct and maintain tortoise-proof fencing around actively used construction and operation sites to lessen the potential for danger from project-related activities.
- Provide escape ramps from trenches; inspect trenches before filling them.

9.3.4.2 General Biological Resources and Soils

Certain herds of migratory animals could be substantially affected if they were prevented from moving between ranges used at different times of the year. Some of the transportation routes under consideration cross game management areas and wild horse and wild burro management areas. Some routes cross areas traversed by herds of antelope, mule deer, elk, and mountain sheep. Fencing would not be likely to affect the movement of mule deer and elk. Fencing could impede the movements of antelope, mountain sheep, wild horses, and wild burros, effectively dividing management areas for these species.

General Biological Resources and Soils Measures Under the Proposed Action

- Use the measures described in Section 9.2.2 to control erosion, dust, and particulate matter and therefore to lessen the consequences for biological resources and soils from transportation activities.

- Use dust suppression measures on disturbed areas to minimize erosion and aid recovery by reducing wind erosion and supporting compaction.

- Conduct preconstruction surveys in floodplains to ensure that work would not affect important biological resources and to determine the reclamation potential of sites.

- Consider measures to relocate sensitive species in floodplains.

- If construction could threaten important biological resources in floodplains, and modification or relocation of the roads and rail line would not be reasonable, develop additional mitigation.

General Biological Resources and Soils Measures Under Consideration

- Mitigate the introduction of contaminants to soils, using methods similar to those described for surface-water impacts (see Section 9.3.3.1).

- Conduct surveys of areas along the transportation corridor selected for construction to locate areas that are potential habitats for sensitive or State-protected species before the beginning of construction activities. Avoid springs, wetlands, waters of the United States, and riparian areas where practicable.

- Reduce habitat fragmentation and barriers to animal movement by considering the needs and movement patterns of mobile species (for example, wild horses) in the design and construction of rail lines, routes, and fencing. Seek input from wildlife agencies and organizations.

- If the construction and operation of a transportation route in Nevada could not avoid springs and wetlands, minimize the amount of disturbance (to the maximum extent possible) by carefully timing construction activities; minimizing corridor widths; locating laydown, excavated rock pile, and fueling areas away from sensitive areas where practicable; and conducting any wetlands replacement activities in accordance with plans approved by the U.S. Army Corps of Engineers.

- Align and locate facilities, roadways, cleared areas, laydown areas, and similar construction activities to minimize fragmentation of habitat potentially affected by the proposed project.

- Mitigate potential soil erosion by minimizing areas of surface disturbance and using engineering practices to stabilize disturbed areas. These practices could include such measures as stormwater runoff control through the use of holding ponds, baffles, and other devices and the compacting of disturbed ground, relocated soil, or excavated material in places outside desert tortoise habitat.

- To aid recovery, strip and stockpile topsoil from disturbed areas. When the disturbed areas were no longer needed, spread the topsoil over the areas and reseed the soil using local seed sources to improve the success of vegetation reestablishment and prevent encroachment of non-native invasive species.

9.3.5 CULTURAL RESOURCES

Land clearing, excavation, and construction activities have the potential to disturb or cause the relocation of cultural artifacts. The operation of industrial facilities can degrade the value of traditional sites or uses. In addition, human activity in project areas causes concern that members of the workforce could affect cultural resource sites, especially those at buried locations or with artifacts.

Actions that DOE would take to mitigate adverse impacts to cultural resources along transportation routes include those required by law or regulation and those built into the project to reduce such impacts. In some cases, DOE cannot identify precise mitigation measures due to the limited nature of the data (for

example, construction activities could reveal previously unidentified sites). To address these cases, DOE has programmatic mitigation measures that comply with historic preservation laws and regulations in place to ensure that it would implement appropriate actions after the identification and evaluation of important cultural resources.

Cultural Resources Measures Under the Proposed Action

- Ensure that onsite employees complete cultural resource sensitivity and protection training to reduce the potential for intentional or accidental harm to sites or artifacts. The training could include descriptions of the importance of different cultural resource types, procedures to follow if resources were encountered in the field, and employment-related and legal penalties for not following the requirements.

- Continue to use the Yucca Mountain Project Native American Interaction Program, which has been in existence since 1985, to promote a government-to-government relationship with Native American tribes and concentrate on the continued protection of important cultural resources. A considerable part of this effort could continue to be directed at protecting these resources and mitigating adverse effects to the fullest extent possible. Historically, as part of this program, members of Native American tribes have made recommendations to DOE about potential adverse effects, mitigation procedures that involve required consultation with tribal governments, and direct involvement of Native Americans in proposed project activities that could affect cultural resources or values (DIRS 102043-AIWS 1998, p. 2-19). AIWS (DIRS 102043-1998, p. 4-1) suggested mitigations such as setting aside important cultural and ceremonial areas, and assisting in revegetation and reclamation activities.

- Conduct preconstruction surveys to ensure that work would not affect important archaeological resources and to determine the research potential of sites.

- If construction could threaten important archaeological resources, and modification or relocation of the roads and rail line would not be reasonable, develop additional mitigation measures.

9.3.6 OCCUPATIONAL AND PUBLIC HEALTH AND SAFETY

Over time, traffic accidents involving vehicles associated with the proposed repository would occur. The analysis indicated that fatalities and injuries from traffic accidents (nonradiological events) probably would constitute the largest impact to public health associated with the project. (See the Occupational and Public Safety and Health sections in Chapters 4 and 6.)

During the transportation of spent nuclear fuel and high-level radioactive waste, drivers and escort personnel would be routinely exposed to radiation and would receive radiological doses from this exposure. Workers and members of the public could receive doses from exposures resulting from an accident that released radionuclides.

Apart from impact findings and mitigations discussed in the EIS, Section 180(c) of the NWPA allows DOE to provide technical assistance and funds to states for training local government and Native American tribal public safety officials through whose jurisdictions DOE could plan to transport spent nuclear fuel or high-level radioactive waste. The training would cover procedures for safe routine transportation and for emergency response situations.

Occupational and Public Health and Safety Measures Under the Proposed Action

- Design task procedures to reduce the potential for accidents that could lead to radioactivity releases in the workplace environment.

Occupational and Public Health and Safety Measures Under Consideration

- Establish contract requirements to minimize worker exposure to ionizing radiation.
- Promote alternative transportation such as buses for workers to reduce automobile accidents.
- Implement a radiation protection plan for drivers and escort personnel.
- Implement accident reduction measures such as the Commercial Vehicle Safety Alliance procedures.

9.3.7 NOISE AND VIBRATION

Noise and vibration impacts could occur along a transportation corridor, depending on the scenario. Native Americans have expressed concern about noise associated with the transportation corridors and the movement of spent nuclear fuel and high-level radioactive waste to the proposed repository (DIRS 102043-AIWS 1998, p. 2-16). Impacts could result from the construction and operation of the facilities associated with transportation. There is concern that transportation activities could disrupt ceremonies that address Native American concerns for ecological health and the solitude needed for healing or prayer. Other communities could be subject to adverse noise and vibration levels, depending on the selected route and the potential to reduce such consequences. DOE expects the potential for adverse impacts from noise and vibration to be low.

Noise and Vibration Control Measures Under Consideration

- Avoid areas with sensitive receptors.
- Avoid Native American ceremonial sites.
- Consider noise and vibration intensity, time and distance, and noise canceling or interference factors when planning construction activities and facilities.
- If the transportation corridor passes through areas close to sensitive human receptors (schools, institutions, etc.), plan for noise abatement walls to reduce noise levels at specific locations.
- If the transportation corridor passes through areas close to structures and facilities that are sensitive to vibration (historic structures), plan for vibration abatement measures such as control of speed at specific locations.
- Install equipment that meets decibel limitations (see Chapter 6).
- Schedule vehicle travel through communities during daylight hours.
- Ensure that the receipt and transfer of material from railcars to heavy-haul trucks at an intermodal transfer station occurred during daylight hours.
- Impose speed limits on train or truck operations to reduce the intensity of noise and vibration in areas where there are sensitive receptors.

9.3.8 AESTHETICS

Construction along transportation routes and at facilities such as intermodal transfer stations and overnight stopping areas could reduce the quality of views in key locations. The operation of intermodal transfer stations and overnight stopping areas would require the lighting of these areas at night.

Aesthetics Measures Under the Proposed Action

- Remove or shape construction spoil piles to reflect existing contours. Keep the height of spoil piles that could not be removed or contoured to a minimum.

- Reclaim borrow areas using native vegetation.
- Plant native seedlings and other vegetation to help screen or reduce texture and color contrasts from key observation locations.
- Conduct an active misting and spraying program during construction to minimize the effects of fugitive dust.
- Reduce effects from outdoor night lighting used for intermodal transfer stations and overnight stopping areas by using measures similar to those discussed for lighting equipment above in Section 9.2.7.

9.3.9 MANAGEMENT OF WASTE AND HAZARDOUS MATERIALS

The manufacture of casks and containers could produce liquid and solid waste streams that would require disposal.

Waste and Hazardous Materials Measures Under the Proposed Action

- Design construction to include use of materials, such as depleted uranium, that could otherwise require disposal as wastes.
- Recycle lubricating and cutting oils.
- Recycle solid waste components where practicable.
- Employ ion exchange and filtration or similar methods to treat water used for ultrasonic weld testing for reuse in the manufacturing process.

REFERENCES

Note: In an effort to ensure consistency among Yucca Mountain Project documents, DOE has altered the format of the references and some of the citations in the text in this Final EIS from those in the Draft EIS. The following list contains notes where applicable for references cited differently in the Draft EIS.

102043	AIWS 1998	AIWS (American Indian Writers Subgroup) 1998. *American Indian Perspectives on the Yucca Mountain Site Characterization Project and the Repository Environmental Impact Statement.* Las Vegas, Nevada: Consolidated Group of Tribes and Organizations. ACC: MOL.19980420.0041.
104618	Buchanan 1997	Buchanan, C.C. 1997. "Final Biological Opinion for Reinitiation of Formal Consultation for Yucca Mountain Site Characterization Studies." Letter from C.C. Buchanan (Department of the Interior) to W. Dixon (DOE/YMSCO), July 23, 1997, File No. 1-5-96-F-307R. ACC: MOL.19980302.0368.
103676	Cowherd, Muleski, and Kinsey 1988	Cowherd, C.; Muleski, G.E.; and Kinsey, J.S. 1988. *Control of Open Fugitive Dust Sources, Final Report.* EPA-450/3-88-008. Research Triangle Park, North Carolina: U.S. Environmental Protection Agency. TIC: 243438.

100248	CRWMS M&O 1997	CRWMS M&O (Civilian Radioactive Waste Management System Management & Operating Contractor) 1997. *Secondary Waste Treatment Analysis.* BCBD00000-01717-0200-00005 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19971208.0201. In the Draft EIS, this reference was cited as DOE 1997l in Chapter 12.
103194	CRWMS M&O 1998	CRWMS M&O (Civilian Radioactive Waste Management System Management & Operating Contractor) 1998. *Efficacy of Relocating Desert Tortoises for the Yucca Mountain Site Characterization Project.* B00000000-01717-5705-00032 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19981014.0309. In the Draft EIS, this reference was cited as DOE 1998h in Chapter 12.
104508	CRWMS M&O 1999	CRWMS M&O (Civilian Radioactive Waste Management System Management & Operating Contractor) 1999. *Repository Surface Design Engineering Files Report.* BCB000000-01717-5705-00009 REV 03. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990615.0238. In the Draft EIS, this reference was cited as TRW 1999a in Chapter 12.
104558	DOE 1988	DOE (U.S. Department of Energy) 1988. *Programmatic Agreement Between the United States Department of Energy and the Advisory Council on Historic Preservation for the Nuclear Waste Deep Geologic Repository Program Yucca Mountain, Nevada.* Washington, D.C.: U.S. Department of Energy. ACC: HQX.19890426.0057. In the Draft EIS, this reference was cited as DOE 1988b in Chapter 12.
103196	DOE 1990	DOE (U.S. Department of Energy) 1990. *Research Design and Data Recovery Plan for Yucca Mountain Project.* Las Vegas, Nevada: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: NNA.19910107.0105.
110625	DOE 1999	DOE (U.S. Department of Energy) 1999. *A Roadmap for Developing Accelerator Transmutation of Waste (ATW) Technology.* DOE/RW-0519. Washington, D.C.: U.S. Department of Energy. TIC: 245890.
156711	DOE 2001	DOE (U.S. Department of Energy) 2001. *The Advanced Accelerator Applications Program Plan.* Washington, D.C.: U.S. Department of Energy, Office of Nuclear Energy, Science and Technology.
103403	National Research Council 1996	National Research Council 1996. *Nuclear Wastes, Technologies for Separations and Transmutation.* Washington, D.C.: National Academy Press. TIC: 226607.
102188	YMP 1995	YMP (Yucca Mountain Site Characterization Project) 1995. *Reclamation Implementation Plan.* YMP/91-14, Rev. 1. Las Vegas, Nevada: Yucca Mountain Site Characterization Office. ACC: MOL.19970109.0256. In the Draft EIS, this reference was cited as DOE 1995g in Chapter 12.

103203 YMP 1997 YMP (Yucca Mountain Site Characterization Project) 1997. *Waste Minimization and Pollution Prevention Awareness Plan.* YMP/95-01, Rev. 1. Las Vegas, Nevada: Yucca Mountain Site Characterization Office. ACC: MOL.19980224.0441. In the Draft EIS, this reference was cited as DOE 1997h in Chapter 12.